

Freeze Resistant Buoy System

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The United States Government has rights in this invention pursuant to contract no. DE-AC05-00OR22725 between the United States Department of Energy and UT-Battelle, LLC.

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CROSS-REFERENCE TO RELATED APPLICATIONS

Specifically referenced is commonly assigned U.S. Patent Application Serial No. _____ filed on even date herewith, entitled “Enhanced Monitor System for Water Protection”, the entire disclosure of which is incorporated herein by reference.

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FIELD OF THE INVENTION

The present invention relates to freeze resistant buoy systems, and more particularly to freeze resistant buoy systems that draw heat from deeper water to prevent freezing of the buoy systems.

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BACKGROUND OF THE INVENTION

Currently available buoy systems may be susceptible to freezing, disabling the activity of systems contained therein. For example, recent terrorist attacks in the United States have increased the awareness of the need for ways to protect drinking water supplies. Source waters for civilian populations and military facilities are vulnerable to such attacks. There is therefore a need for improved real-time water quality sensor systems that quickly and accurately detect toxic materials in a water source and transmit an indicative signal. In climates where water supplies freeze over during cold seasons, there is a need to protect such systems, and other buoy-mounted systems, from freezing.

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Specifically referenced is commonly assigned U.S. Patent No. 6,569,384 issued on May 27, 2003 to Greenbaum, et al. entitled “Tissue-Based Water Quality Biosensors for Detecting Chemical Warfare Agents”, the entire disclosure of which is incorporated herein by reference.

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Specifically referenced is U.S. Patent No. 3,170,299 issued on February 23, 1965 to Clarke, entitled “Means for Prevention of Ice Damage to Boats, Piers, and the Like”, the entire disclosure of which is incorporated herein by reference.

OBJECTS OF THE INVENTION

Accordingly, objectives of the present invention include provision of buoy systems that are
5 resistant to freezing, buoy systems that draw heat from deeper water to prevent freezing of
the buoy systems, and means for protecting water supplies, especially primary-source
drinking water, in cold climates. Further and other objects of the present invention will
become apparent from the description contained herein.

10 SUMMARY OF THE INVENTION

In accordance with one aspect of the present invention, the foregoing and other objects are
achieved by a freeze resistant buoy system which includes a tail-tube buoy having a
thermally insulated section disposed predominantly above a waterline, and a thermo-siphon
disposed predominantly below the waterline.

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In accordance with another aspect of the present invention, a freeze resistant buoy system
includes a tail-tube buoy having a thermally insulated section disposed predominantly above
a waterline, a thermally conducting section disposed predominantly below the waterline, and
a system housed within the buoy system for collecting and analyzing samples.

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BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a cutaway view of an embodiment of the present invention that employs a
thermo-siphon.

25 Fig. 2 is a cutaway view of an embodiment of the present invention that employs a
thermally conductive lower section, and contains a system for detecting toxic agents in a
water supply.

For a better understanding of the present invention, together with other and further objects,
30 advantages and capabilities thereof, reference is made to the following disclosure and
appended claims in connection with the above-described drawings.

DETAILED DESCRIPTION OF THE INVENTION

Referring to Fig. 1, the present invention is a tail-tube buoy system 200 that is adapted for deployment in colder climates. There are two essential parts to the buoy system 200, an upper section 220, which is disposed predominantly above the water line 216, and a lower section 202, which is disposed predominantly below the waterline 216. An anchoring ring 226 can be attached, for example to the bottom of the buoy 200. A buoyant stabilizing wing or collar 224 can be attached, for example, at the waterline 216.

The upper section 220 is comprised of a thermally insulating material 222, and, optionally, an inner liner 244 to provide structural integrity. The thermally insulating material 222 is preferably comprised of a suitable, commercially available insulation. Suggested examples are: blown foam; polystyrene foam; fiberglass; carbonaceous insulations such as Fiberform™ available from Fiber Materials, Inc., Selkirkshire, Scotland, UK; and carbon foam such as that available from ERG Materials and Aerospace Corporation, Oakland, California, Ultramet, Pacoima, California and Touchstone Research Labs, Ltd., Triadelphia, West Virginia. The thermally insulating material 222 protects the interior 230 of the buoy 200 from overheating in warm seasons, and from freezing in cold seasons. A conventional coating, layer, panel, or other type of shield may also be used therewith to shield the upper section 220 from direct sunlight, precipitation, and/or other environmental hazards.

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The lower section 202 of the buoy 200 is thermally conductive. The thermally conductive lower section 202 is preferably inserted up inside the insulated upper section 220 in order to heat and/or cool the interior 230 above the waterline 216. Moreover, the thermally conductive lower section 202 can be made vertically contiguous in order to promote optimal heat transfer characteristics.

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In one embodiment of the present invention, as shown in Fig. 1, the lower section 202 further comprises a thermo-siphon for efficiently transferring sensible heat from the bottom 204 to the water line region 206. The thermo-siphon 202 comprises an outer shell 210, and inner shell 212, with a hollow space 214 therebetween – similar in construction to a Dewar flask. A highly thermally conductive porous heat-exchange material, such as graphite foam described in U.S. Patent No. 6,033,506, for example, 208 can be bonded into the bottom 204. The hollow space 214 is evacuated and partially backfilled with a heat

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transfer fluid such as water, fluorinert™ (available from Hampton Research, 34 Journey, Aliso Viejo, CA 92656-3317), acetone, or alcohol, for example.

5 The thermo-siphon 202 operates as follows: Sensible heat from deeper water 240 warms the bottom 204, and the porous material 208. The heat transfers to the heat transfer fluid which evaporates and rises to the waterline region 206. The heat transfer fluid condenses on the coldest part of the thermo-siphon 202, transferring the heat to the waterline region 206. The latent heat of condensation is usually sufficient to keep ice from forming, thus keeping the buoy free. The condensate then drains down to the bottom 204 for recycle and
10 further evaporation. Hence, a totally passive vapor chamber rapidly transfers sensible heat from deeper water to the waterline region 206 of the buoy. The fluid transfer rate will change to accommodate the changes in heat duty due to environmental changes. Hence, during colder weather, more vapor will be generated, and during warmer weather, virtually no vapor will be generated. Selection of heat transfer fluid can be made with
15 considerations of estimated service location, duty cycle, heat duty of the system, environmental conditions, and other factors.

The thermo-siphon 202 can be extended below the bottom of the buoy, or the buoy itself can be elongated in order to reach deeper, warmer water 240. Moreover, the thermo-siphon 202
20 may be enhanced by increasing the surface area of internally and/or externally thereof by any known means, such as, for example, flutes, fins, perforations, folds, etc. Fins 232 are shown at the bottom 204 in Fig 1 as an example.

The Buoy can house a variety of mechanical, chemical, biological, electrical, electronic,
25 sonic, optical, and/or other systems for collecting and analyzing samples of air, water, electromagnetic energy, other types of energy, and other materials.

In another embodiment of the present invention, shown in Fig, 2, the present invention includes a remotely controlled, buoyant device for detecting toxic agents in water sources
30 using chlorophyll fluorescence monitoring. This device, described in U.S. patent Application Serial No. _____, is designed to make rapid remote assessments of possible toxic contamination of source waters (reservoirs, rivers, lakes, etc.) prior to entry to drinking water distribution systems. It provides around-the-clock unattended monitoring and uses naturally

occurring aquatic photosynthetic tissue as the sensing material. The present invention can be used as a first-alert warning system for terrorist attacks on, and/or accidental spills into municipal and military drinking water supplies. The present invention can operate continuously, periodically, or responsively to an externally generated signal.

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Referring to Fig. 2, a tail-tube buoy 10 houses the water quality monitoring system in the interior 30 thereof. The buoy 10 comprises an upper section 12, which is disposed predominately above the water line 16, and a lower section 14, which is disposed predominately below the waterline 16. An anchoring ring 26 is usually attached to the
10 bottom of the buoy 10. A buoyant stabilizing wing or collar 28 is usually attached at the waterline 16.

The upper section 12 is comprised of a thermally insulating material 18 and, optionally, an inner liner 20 to provide structural integrity. The thermally insulating material 18 protects the
15 interior 30 from overheating in warm seasons, and from freezing in cold seasons. A conventional coating, layer, panel, or other type of shield may also be used therewith to shield the upper section 12 from direct sunlight, precipitation, and/or other environmental hazards.

20 The lower section 14 is preferably comprised of a thermally conductive material 22 and, optionally, an inner liner 24 to provide structural integrity and/or a waterproof seal. The thermally conductive material 22 protects the buoy 10 from becoming frozen during periods when a layer of ice forms on the surface 16 of the water 4. Sensible heat from deeper, warmer water is transferred upward to protect the interior 30 and equipment housed therein
25 from freezing. Moreover, a layer of unfrozen water will remain around the buoy 10. Thus, the water monitoring system can continue to operate.

The selection of thermally conductive material 22 is based upon the specific climate of the location where the buoy is to be deployed. In temperate climates where ice formation is
30 generally limited to no more than a few inches, the thermally conductive material 22 can be comprised of metal, for example, aluminum and/or copper. In such cases, an inner liner 24 is not generally necessary because the metal provides structural integrity and a waterproof seal.

Deployment of the buoy in progressively colder climates requires progressively greater capacity for transferring heat. This can be accomplished using, for example, a very high thermal conductivity graphite fiber composite material or graphite foam material as the thermally conductive material 22. Moreover, the thermally conductive material 22 can be
5 extended below the bottom of the buoy, or the buoy itself can be elongated in order to reach deeper, warmer water. Moreover, the thermally conductive material 22 may be enhanced by increasing the surface area thereof by any means, such as, for example, flutes, fins, perforations, folds, etc.

10 Fig. 2 further shows a pump 40, which causes water to flow into the water quality monitoring system through an inlet 42, and influent tube 44, into a fluorometer 46, through an effluent tube, 48, and outlet 50. Location of the pump, inlet 42, outlet 50, and routing of the inlet and outlet tubes 44, 48 are not critical to the invention.

15 The fluorometer 46 is essentially as described in U.S. patent No. 6,569,384, referenced hereinabove. The inlet 42 may comprise a filter, screen, baffle, or other device to prevent solid materials from entering the influent tube 44. The pump 40 may be located anywhere along the inlet tube 44 or outlet tube 48. The pump 40 and fluorometer 46 are controlled by an electronics package 52 housed in the interior 30 and have respective electrical
20 connections 54, 56 thereto.

A power supply 58, such as a deep-cycle battery, is also housed in the interior 30, and has electrical connection 60. A solar panel 62 or other device for harnessing natural energy is optionally mounted on the buoy 10, optionally with a support bracket 70 or the like, and
25 has an electrical connection 64 to the electronics package 52, as shown, or directly to the power supply 58. The solar panel 62 preferably charges the battery 58. The electronics package 52 preferably monitors the power level, controls recharging cycles, and detects low battery and failure conditions. An antenna 66 is mounted on the buoy 10 and has an electrical connection 68 to the electronics package 52.

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The invention can be integrated into a common data highway comprising comprehensive sets of homeland security sensors to provide rapid incident management in case of a water contamination event at susceptible real-time water monitoring locations. By strategically

locating and connecting water sensors on existing commercial and government infrastructures, critical information can be sent to a command center within minutes of an event.

5 The ultimate goal is real-time, reliable, and secure transmission and processing of data and information for the accurate prediction of the event location, identification of the threat, its directional path over time, and the number of people that could be affected. By receiving this information on a real-time basis, the command center can immediately dispatch water facility managers and first responders to the event area.

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Provided with such detailed information from the common data highway, effectiveness of the first responders will be greatly enhanced. They will have fast, accurate, and precise information available relating to the type of toxic agent involved and immediately execute the appropriate treatment. Also, if necessary, areas in the projected path of the toxic agent release
15 can be evacuated in advance. The enhanced water monitoring system can be integrated to assure an ultra-high level of reliability, survivability and security, especially where the common data highway is scalable across state, local, and federal governments.

See, for example, commonly assigned U.S. Patent Application Serial No. 10/370,913 filed on
20 February 21, 2003 entitled "System for Detection of Hazardous Events", the entire disclosure of which is incorporated herein by reference.

While there has been shown and described what are at present considered the preferred embodiments of the invention, it will be obvious to those skilled in the art that various
25 changes and modifications can be prepared therein without departing from the scope of the inventions defined by the appended claims.